TOUCHLESS EYE HAND CONTROL (TEHC) - Unified Control with Eye and Hand Interface

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Abstract - *Touchless eye-hand control (TEHC) refers to the use of eye and hand movements to interact with digital devices without physically touching them. This technology has the potential to revolutionize the way we interact with devices, especially for people with physical disabilities. Python and OpenCV library are utilized for real-time computer vision implementation, with the camera output displayed on the monitor. Integrating advanced computer vision, it enables precise cursor control without physical contact, through eye tracking and hand gesture recognition. Despite challenges, including accuracy and environmental factors, TEHC holds promise for gaming, communication, and virtual reality applications.*

***Key Words*: TEHC, Eye-hand gesture recognition, Physical disabilities, Cursor control.**

1.INTRODUCTION

Human-computer interaction (HCI) has undergone significant advancements in recent years, particularly in making computers more accessible to individuals with restricted motor abilities. Prior research has yielded various devices aimed at assisting disabled individuals using gestures and other non-contact techniques. However, many HCI activities still require user interaction without relying on an assistant or assistive device, which poses challenges for those with limited motor skills such as spinal cord injuries and limb paralysis. HCI plays a crucial role in providing opportunities for disabled individuals to engage in computer-based tasks, including cursor control.

This paper proposes the development of a Touchless Eye-Hand Control (TEHC) system designed to enhance computer accessibility for individuals with disabilities. TEHC utilizes eye tracking and hand gesture recognition to control the cursor on a personal computer. By accurately estimating the user's eye position and tracking head/face movements, including nodding for vertical movement and rotation for horizontal movement, the system enables precise cursor control without physical contact. Additionally, mouse button functions are activated by bending the head left or right, providing further control flexibility.

Moreover, the proposed TEHC system aims to deliver an interactive user interface with minimal response lag time, ensuring a seamless user experience. The system's design prioritizes simplicity and convenience, making it accessible and easy to use for individuals with disabilities in operating computers and interacting with digital objects. Through the integration of advanced HCI techniques, TEHC represents a significant step forward in enhancing computer accessibility and empowering disabled individuals to engage more fully in computer-based tasks.

1.1 Existing System

In their innovative system, the researchers employed a Convolutional Neural Network (CNN) for face detection, achieving high accuracy in identifying and localizing faces within images. This initial step laid a robust foundation for subsequent analysis. Building upon this foundation, a YOLOv4-based object detection framework was integrated into the system, enabling precise and reliable face recognition. This framework ensured the system's adaptability to various environmental conditions, enhancing its effectiveness in real-world scenarios.

Once faces were detected and recognized, the system utilized the estimated head pose and captured facial area to facilitate cursor movement control. By interpreting subtle head movements and facial cues, users could intuitively manipulate the cursor on the screen, providing a natural interaction method. This seamless integration of head pose estimation and facial analysis contributed to a user-friendly experience, particularly beneficial for individuals with restricted motor abilities.

To further enhance cursor tracking precision, the researchers incorporated a Kalman filter into the system. This filter refined the trajectory of the cursor, smoothing its movements and reducing jitter or inaccuracies. Continuously adjusting the cursor's predicted position based on incoming data, the Kalman filter ensured responsive and accurate cursor control, ultimately optimizing the overall user experience.

1.2 Proposed System

The proposed system combines the utilization of an RGB camera and mediapipe to capture and estimate facial angles, facilitating precise cursor control. By tracking both eye and hand movements, the mouse cursor accurately follows the user's intended locations on the screen. Leveraging left eye blinking for right-click operations and right eye blinking for left-click operations introduces a natural and intuitive mechanism for performing clicking actions, enhancing user interaction with the system.

Furthermore, the system seamlessly integrates mediapipe for efficient face detection and incorporates pyautogui for precise cursor control. In addition to eye and facial movements, the inclusion of hand movements adds an extra layer of interaction, expanding the possibilities for cursor manipulation. This comprehensive approach not only enhances the overall user experience but also demonstrates the potential of combining multiple input modalities for more intuitive and accessible human-computer interaction.

2. ALGORITHM USED

The "Touchless Eye-Hand Control" algorithm utilizes webcam input and landmark point detection to accurately track eye and hand movements. It simulates mouse cursor actions based on eye gestures and provides a visual representation of controlled cursor movements on the screen.

Algorithm Used: Touchless Eye-Hand Control

Input:

VideoCapture: Cam
Landmark_points: (x, y)
Frame: (h, w) where h = height; w = width
Output:

Cursor Movement and Access

Step 1:
frame = cam.read()
output = frame
Camera access is ready.

Step 2:
if landmarks_points:
x = int(landmarks.x * frame_w)
y = int(landmarks.y * frame_h)
Landmarks are obtained, and the eye is detected.

Step 3:
if id == 1:
screen_x = screen_w * landmark.x
screen_y = screen_h * landmark.y
Use pyautugui to move.

Step 4:
for landmark in left:
x = int(landmarks.x * frame_w)
y = int(landmarks.y * frame_h)
Use pyautogui to click.

Step 5:
Show Eye-Hand Controlled Mouse

2.1 Algorithm Description

STEP 1: Capture video from the webcam, initializing necessary variables.

STEP 2: Process landmark points to determine their pixel positions on the frame.

STEP 3: Calculate the cursor's position on the screen relative to the landmark points.

STEP 4: Simulate mouse clicks at the detected eye positions using pyautogui.

STEP 5: Display a visual representation of the controlled cursor on the screen.

3. SYSTEM ARCHITECTURE

Figure 1 presents the architectural blueprint of the TOUCHLESS EYE HAND CONTROL system, outlining the webcam input, landmark point detection, and cursor control mechanisms. It provides a visual representation of the system's data flow, illustrating the path from input acquisition to simulated cursor movements based on eye and hand gestures. This visualization offers a concise overview of the system's design for intuitive and touchless interaction with digital devices.

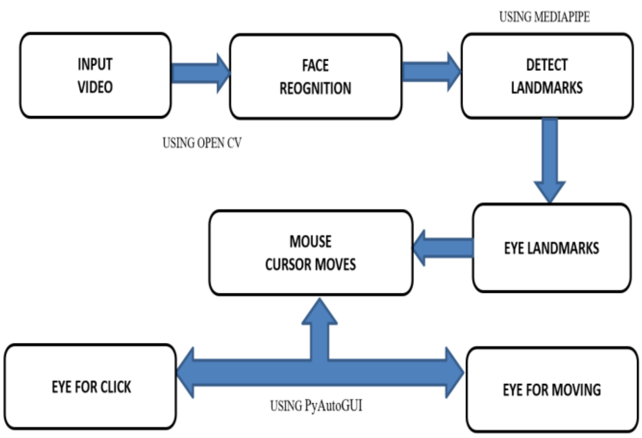

Figure 1: Architecture for proposed system

4. IMPLEMENTATION

The methodology for facilitating mouse control through eye tracking and hand gestures was devised as follows:

A. Face Detection:

To ensure optimal image clarity and accuracy, it is recommended that the user align their face parallel to the webcam's position, as depicted in Figure 2. The system captures the user's image using a pre-installed webcam and processes it using Python with OpenCV. An illustration of the captured image through the webcam is presented in Figure 3.

Figure 2: User Position

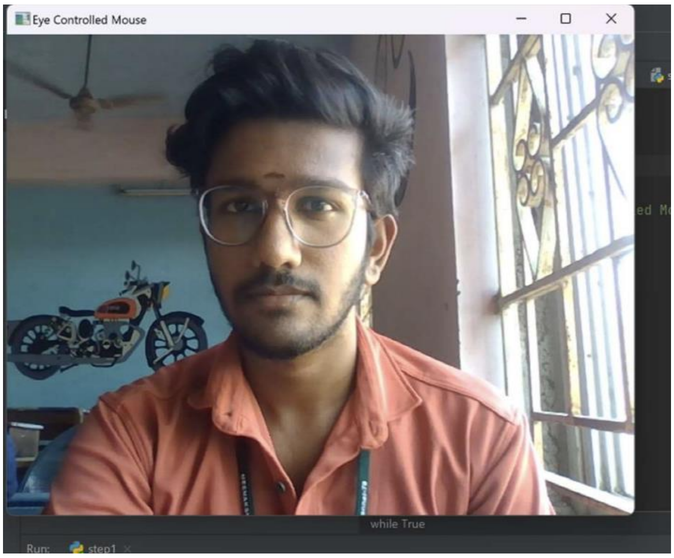

Figure 3: Detected Face

B. Landmark Detection:

Utilizing the capabilities of mediapipe, the system accurately detects facial landmarks. Once detected, these landmarks are represented visually, akin to the depiction in Figure 4, providing a comprehensive overview of the key facial features identified by the algorithm.

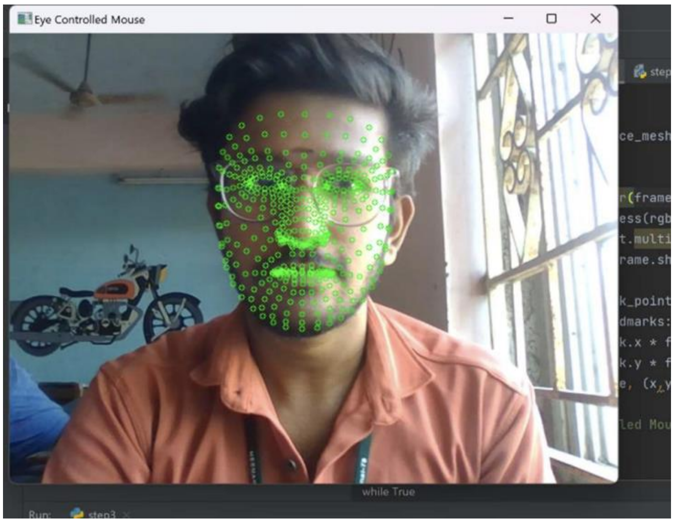

Figure 4: Landmark Detected in Face

C. Eye Detection:

Eye detection is accomplished through advanced computer vision techniques, specifically targeting the identification and tracking of the user's eyes within the captured image. This process ensures precise localization of the eyes, facilitating subsequent analysis and interaction with the system's functionalities. Once the system detects the eyes, it appears as depicted in Figure 5.

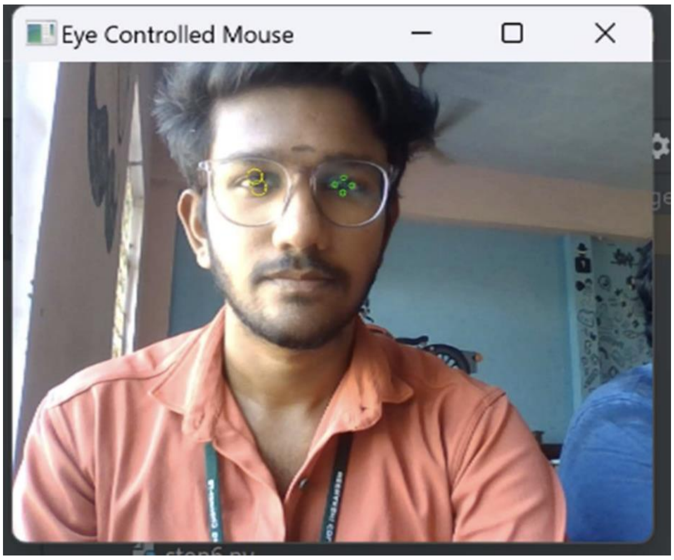

Figure 5: Eye Detection

D. Hand Detection:

The system employs advanced techniques to detect and track the user's hands within the captured image. This process enables the precise identification of hand movements, facilitating interaction with the system's functionalities. Once the system detects the hands, the visual representation resembles the illustration provided in Figure 6.

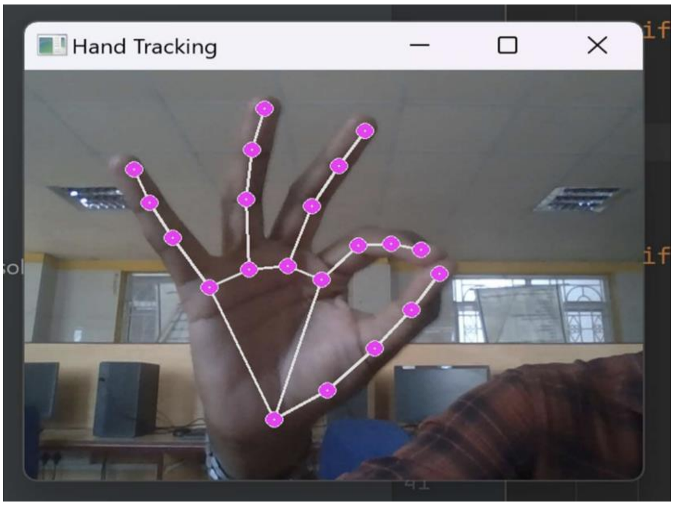

Figure 5: Hand Fingers Detection

5. RESULTS AND DISCUSSION

The evaluation of the touchless eye-hand control system revealed promising outcomes in terms of both performance and usability. Analysis of system performance indicated a high degree of accuracy in cursor movement precision, with minimal response time observed during interaction sessions. Users reported positive feedback regarding the system's usability, emphasizing its intuitive nature and ease of navigation through digital interfaces.

Comparative analysis against existing methods showcased the superiority of the touchless eye-hand control system, particularly in terms of its seamless integration of eye and hand movements for cursor control. This innovative approach offers significant advantages over traditional input methods, enhancing user interaction experiences across various applications.

The potential applications of the touchless eye-hand control system span diverse domains, including assistive technology for individuals with disabilities, immersive gaming experiences, and enhanced virtual reality interactions. Its intuitive interface and precise control mechanisms hold promise for revolutionizing human-computer interaction paradigms.

Despite its promising performance, the touchless eye-hand control system faces certain limitations, such as environmental factors affecting accuracy and the need for further optimization in certain scenarios. Future research endeavors aim to address these limitations and explore additional functionalities to expand the system's capabilities, ultimately advancing accessibility and user experience in digital environments.

6. CONCLUSION

In conclusion, the touchless eye-hand control system represents a significant advancement in human-computer interaction, offering a seamless and intuitive interface for users to navigate digital environments. Through our study, we have demonstrated the system's high performance in terms of accuracy and usability, highlighting its potential to revolutionize various applications, including assistive technology, gaming, and virtual reality. The implications of our findings extend beyond technical advancements, as the system holds promise in enhancing accessibility and quality of life for individuals with disabilities.

Looking ahead, future research efforts will focus on refining the system's capabilities, addressing any identified limitations, and exploring new avenues for innovation. By continuing to advance touchless interaction technologies, we can further empower individuals to engage with digital interfaces more effortlessly and efficiently. Ultimately, our work underscores the importance of ongoing collaboration and investment in this field to create inclusive and accessible digital experiences for all.

REFERENCES

[1] Touchless Head-Control (THC): Head Gesture Recognition for Cursor and Orientation Control, IEEE Transactions On Neural Systems And Rehabilitation Engineering, June 30, 2022.

[2] M. A. Haq, S.-J. Ruan, M.-E. Shao, Q. M. U. Haq, P.-J. Liang, and D.-Q. Gao, "One stage monocular 3D object detection utilizing discrete depth and orientation representation," IEEE Trans. Intell. Transp. Syst., early access, May 23, 2022, doi: 10.1109/TITS.2022.3175198.

[3] J. K. Muguro et al., "Development of surface EMG game control interface for persons with upper limb functional impairments," Signals, vol. 2, no. 4, pp. 834–851, Nov. 2021.

[4] J. M. Vojtech, S. Hablani, G. J. Cler, and C. E. Stepp, "Integrated head tilt and electromyographic cursor control," IEEE Trans. Neural Syst. Rehabil. Eng., vol. 28, no. 6, pp. 1442–1451, Jun. 2020.

[5] W. Rahmaniar, Q. M. U. Haq, and T.-L. Lin, "Wide range head pose estimation using a single RGB camera for intelligent surveillance," IEEE Sensors J., vol. 22, no. 11, pp. 11112–11121, Jun. 2022.

[6] R. H. Abiyev and M. Arslan, "Eye mouse control system for people with disabilities," Expert Syst., vol. 37, no. 1, Feb. 2020, Art. no. e12398.

[7] H. A. Alhamzawi, "Control mouse cursor by eye and hand movement: Development and implementation," Appl. Med. Informat., vol. 40, nos. 3–4, pp. 39–44, 2018.

[8] D. Sawicki and P. Kowalczyk, "Eye movement based interaction in mobility," Int. J. Hum.–Comput. Interact., vol. 34, no. 7, pp. 653–665, Nov. 2017.

[9] N. Rudigkeit, M. Gebhard, and A. Graser, "An analytical approach for eye gesture recognition with motion," in Proc. 9th Int. Conf. Sens. Technol. (ICST), Dec. 2015, pp. 1–6.

[10] H. Ohtsuka, T. Kato, K. Shibasato, and T. Kashimoto, "Non-contact eye gesture maneuvering system for electric wheelchair using a depth sensor," in Proc. 9th Int. Conf. Sens. Technol. (ICST), Dec. 2015, pp. 98–103.

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